

PATENT SPECIFICATION



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441,461

" " Sept. 27, 1934. No. 27742/34.

One Complete Specification Left: April 11, 1935.

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Specification Accepted: Jan. 13, 1936.

PROVISIONAL SPECIFICATION

No. 10954 A.D. 1934.

Improvements in and relating to Control Systems for Colour Lighting Apparatus

We, HOLOPHANE LIMITED, a company organised and existing under the laws of Great Britain and Northern Ireland, and ROLLO GILLESPIE WILLIAMS, a British subject, both of Holophane House, Elverton Street, Vincent Square, London, S.W.1. do hereby declare the nature of this invention to be as follows:—

This invention relates to control apparatus for colour lighting systems of the type comprising in each lighting unit a number, for example three or four, of group of lamps each group being of different colour, and each group having dimmer control so that various colour mixtures can be set up. Such a system may comprise any number of lighting units which may be arranged for separate, grouped, or simultaneous control as desired.

Though an infinite variation of colour is theoretically possible in such a system, in practice it is sufficient to provide a series, say twelve, definite combinations, with say three strengths of white light in addition. Control mechanism achieving this end is disclosed for example in the specification of our Patent No. 396,790 and another mechanism achieving this end is disclosed in the co-pending application No. 36212/32. The present invention is in some respects a development based on these two prior specifications whereby the convenience of control of the former is combined with the simplicity of the latter, the duplication necessary in the former specification to effect presetting being avoided. Briefly stated the present invention comprises a step controller (for example a hand wheel) which determined the stopping positions of a hunting switch or switches themselves actuated by or in conjunction with the dimmers. At each step of the controller a different colour combination is obtained, but the controller can be moved directly from any one position to any other and there will be a direct but gradual or "dis-

solving" change from the colour combination set up in the first position to that set up by the second position; generally speaking therefore there will be no need to provide duplicate controls for presetting.

Where desired, any white lights which may be used in varying degrees of strength to obtain pastel colours may be provided with a separate controller.

The circuits may in general be on the same lines as those disclosed in application No. 36212/32 above referred to, but if a hand wheel controller is used the arrangements there provided to make only one key effective if several are depressed simultaneously and for key cancelling will be unnecessary. Relays, conveniently operated at low voltage, may be used to prevent mutually interfering circuits from being set up, or the various contacts actuated by the controller may be kept separate to this end. Where heavy currents are involved they may be controlled through contactors.

The dimmers may be driven each by its own contactor controlled reversible motor, or each such motor may rotate in constant direction and be provided with gearing driving two shafts in opposite directions either of which may be coupled to the dimmer by an electromagnetic clutch, or the like controlled by the associated hunting switch. In some cases a single motor can control a number of dimmers say through cams, or the dimmers can be separately clutchable to either of two common shafts rotating in opposite directions.

In a convenient arrangement of control board there is a panel for each unit on which a hand control wheel is provided and beneath it two switches, for instance press button switches, for each colour in the unit (usually there will be three colours, red, green and blue). In the off position of both of these switches the corresponding colour in the unit will be controlled by the hand wheel, when one

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is actuated the respective colour will be brought full on and when the other is actuated, cut right out, irrespective of the hand wheel position. Alternatively 5 two way and off switches may be used, one for each colour. If white light is provided in addition, this is preferably controlled by a smaller hand wheel concentric with the first.

10 Preferably a master control corresponding with each item in the unit control is provided to which the control of each unit can be transferred separately or in groups. This may be done mechanically or by the use of clutches, or electrically as by the use of a throw over 15 switch connected with each item in the

unit control or with groups of items in each unit control.

In place of hand wheels any other convenient step controller may be provided, say a lever working in a slot. The various steps will be marked in any convenient way. In the case of a hand wheel, this may be continuously rotatable and 25 may go through the complete range more than once per revolution.

Dated this 11th day of April, 1934.

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PROVISIONAL SPECIFICATION

No. 27742 A.D. 1934.

Improvements in and relating to Control Systems for Colour Lighting Apparatus

We, HOLOPHANE LIMITED, a company organised and existing under the laws of Great Britain, and ROLLO GILLESPIE WILLIAMS, a British subject, both of Holophane House, Elverton Street, Vincent Square, London, S.W.1. England, do hereby declare the nature of this invention to be as follows:—

This invention relates to control systems for colour lighting apparatus in which mixtures of light of different colours are obtained by brightness control of lamps or groups of lamps of several 40 colours. Such apparatus can conveniently comprise a number of lighting units each including a number, for example three or four, of groups of lamps of different 45 colours and they may be arranged for separate, grouped, or simultaneous control, as desired.

Briefly stated the present invention consists in the use of multi-electrode tubes or valves for brightness control. One or more 50 lamps or lamp groups are connected in the output circuit of a tube or valve and the control is applied through the appropriate electrode. This system has the advantage of eliminating dimming resistances in the lamp circuits with their consequent waste of current and generation of heat requiring to be dissipated.

The tubes or valves may be of the three-electrode high-vacuum type, but since the anode current of such tubes is ordinarily rather low, it is preferred to use gas filled tubes with grid controlled arc discharges, operated with alternating 60 current.

The tube grids can be controlled by

any desired system of switching. For example the circuits disclosed in the specification of our Patent No. 396,790 or of Patent No. 412,217 can be used or adapted for the end in view. Since the grid currents are negligible, contactors can be eliminated and the dials or other control members can control the necessary potentials or resistances directly, care 75 being taken to keep circuits which might interfere with one another separate as by the use of separate contacts. Alternatively the control may be arranged to be operated as in our pending application No. 10954/34.

Where desired any white lights which may be used in varying degrees of strength to obtain pastel colours may be provided with separate controllers. There may also be additional switches which give full on and off irrespective of the position of the main controller and such additional switches may be provided separately for each colour. Where there 90 are a number of controllers one for each lighting unit or for sets of lighting units, a master controller may also be provided to which the unit controls can be transferred separately or in groups either mechanically as by the use of clutches or electrically as by the use of throw-over 95 switches.

Dated this 27th day of September, 1934.

SEFTON-JONES, O'DELL & STEPHENS,

Chartered Patent Agents,
285, High Holborn,
London, W.C.1.

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COMPLETE SPECIFICATION

Improvements in and relating to Control Systems for Colour
Lighting Apparatus

We, HOLOPHANE LIMITED, a company organised and existing under the laws of Great Britain and Northern Ireland, and ROLLO GILLESPIE WILLIAMS, a British subject, both of Holophane House, Elverton Street, Vincent Square, London, S.W.1. do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to control systems for colour lighting apparatus of the type comprising in each lighting unit a plurality of coloured light sources (say three or four groups of lamps some or all with colour filters) each source having brightness control so that various colour mixtures can be set up. Such apparatus may comprise any number of lighting units which may be arranged for separate, or simultaneous control as desired.

It has already been proposed in a control system for colour lighting apparatus of the above type, to provide each colour in a unit with its own motor driven reversible dimmer and to provide limit switches in the path of the dimmer arm through which switches the drive mechanism was supplied from a step switch so that when the dimmer arm reached the particular limit switch being supplied from the step switch the supply to the driving mechanism was broken and the dimmer came to rest; but the limit switches were only make and break switches and a further switch additional to the limit switches and the step switch had first to be set by hand to bring about the correct direction of motion of the dimmer arm. Further in this prior proposal a separate step switch was provided for each separate colour in a lighting unit. Another known system also controls each colour separately and makes use of a Wheatstone bridge circuit and polarised relay to control the operation and direction of motion of the dimmer, a step switch enabling the operator to adjust one arm of the bridge and the other arm being adjusted by a wiper on the dimmer arm so that the dimmer arm moved towards a balanced position determined by the setting of the step switch and at this position the flow of current through the relay ceased and the drive was interrupted.

Though an infinite variation of colour is theoretically possible in such a system,

in practice it is sufficient to provide a series of definite combinations, say twelve, with say three strengths of white light in addition. Control mechanism achieving this end is disclosed for example in the specification of our Patent No. 396,790 and another mechanism achieving this end is disclosed in the specification of Patent No. 412,217 dated prior to the date of this application but published after it. The present invention is in some respects a development based on these two prior specifications whereby the convenience of control of the former is combined with the simplicity of the latter the duplication necessary in the former specification to effect presetting being avoided. Briefly stated the present invention comprises a controller in the form of a step switch (operated for example by a hand wheel) and hunting switches associated with the brightness controls, said step switch determining the stopping positions of all hunting switches associated with one lighting unit and themselves actuated by or in conjunction with the brightness control. By hunting switch we mean a switch which directs a supply of current coming from the said step switch into that one of two circuits which operate the brightness control in opposite directions which will bring the brightness control to the desired position corresponding with the setting of the said step switch, whatever the starting position of the brightness mechanism may be, and breaks the said supply when the desired position is reached.

If for convenience the terms upward and downward be used to describe the motion of the brightness control and the associated member of the hunting switch our hunting switch in effect comprises a series of terminal elements one for each desired stopping position and each connected to the appropriate point or points of the step switch, means for connecting each said terminal element to the mechanism for moving the brightness control in both upward and downward directions and a breaking member moving by or in conjunction with the brightness control, which at each stopping point of the brightness control breaks the circuit at the corresponding terminal element and leaves those elements above the break connected to the mechanism for providing upward movement of the brightness con-

5 trol and these elements below the break
 connected to the mechanism for provid-
 ing downward movement of the brightness
 control. Conveniently the breaking mem-
 10 ber comprises a shaft with cams thereon
 which actuates movable switching ele-
 ments in turn, for instance a finger con-
 nected to the appropriate point or points
 of the step switch and moving between
 15 terminals connected to the mechanism for
 providing the respective directions of
 movement of the brightness control. The
 brightness control may be effected directly
 i.e. by variable resistance or so-called
 20 dimmer in series with each colour group
 in each unit, such dimmers being for ex-
 ample motor actuated, and the hunting
 switches being actuated by the dimmer
 mechanism. Or the brightness control may
 25 be effected indirectly, as by the use of
 multi-electrode discharge tubes or valves,
 the control being applied to the grids; in
 the latter case suitable motor actuated
 resistances or potentiometers can be pro-
 30 vided for grid potential control and as
 with direct brightness control the hunting
 switches are actuated by the resistance or
 potentiometer mechanism. For con-
 venience the term dimmer will be used
 hereinafter to denote the variable resis-
 35 tances used for both types of control. At
 each step of the controller a different
 colour combination is obtained, but the
 controller can be moved directly from any
 40 one position to any other and there will
 be a direct but gradual or "dissolving"
 change from the colour combination set
 up by the first position to that set up by
 the second position; generally speaking
 45 therefore there will be no need to provide
 duplicate controls for presetting.

Where desired, any white lights which
 may be used in varying degrees of
 strength may be provided with a separate
 50 controller.

The dimmers may be driven by any con-
 venient means, say each by its own con-
 tactor controlled reversible motor, or by
 mechanism which moves in constant
 55 direction but is provided with two mem-
 bers moving the dimmer in opposite direc-
 tions either of which may be put in action
 by an electromagnetic clutch, or the like
 controlled by the associated hunting
 60 switch. In some cases a single motor can
 control a number of dimmers say through
 cams as described with reference to
 Figure 3 in specification No. 412,217, or
 the dimmers can be separately clutchable
 65 to either of two common shafts rotating
 in opposite directions.

The step controller may as above stated
 be a hand actuated member, or where a
 repeating cycle of changes is desired it
 70 may be stepped on by a motor drive. It

may comprise a wiper coacting with studs,
 or cam discs on a shaft which close con-
 tacts energising the hunting switches.
 The motor drive may be such as to allow
 the phase relationship of one controller
 75 to be changed with respect to another. In
 this connection, the schemes proposed in
 our specification No. 411,868 may be used.

In place of hand wheels any other con-
 venient step controller may be provided,
 say a lever working in a slot. The various
 steps will be marked in any convenient
 way. In the case of a hand wheel, this
 may be continuously rotatable and may
 80 go through the complete range more than
 once per revolution.

The invention will be further described
 with reference to the accompanying draw-
 ings in which

Figure 1 is a front elevation of the
 control board for a colour lighting system
 in which there are five three-colour light-
 85 ing units,

Figure 2 is an incomplete circuit
 diagram for a system having three-colour
 90 units and employing direct brightness
 control.

Figures 3 and 4 are respectively a side
 view and plan of one form of direct con-
 95 trol mechanism.

Figures 5 and 6 are respectively an end
 view and side view of the hunting switch.

Figure 7 is a detail of a preferred con-
 struction of hand control member.

Figure 8 is a diagram of a motor device
 for mechanically effecting a repeating
 100 cycle of changes.

In Figure 1 the control board has five
 panels 1 each associated with a corres-
 ponding unit or units, and the master
 105 controls, described further below, are for
 convenience, provided on the central
 panel. On each panel there is a main step
 controller, here in the form of a hand
 wheel 2 on a shaft 2a and arm 3 coacting
 110 with a dial 4 the various positions along
 which correspond with a desired range of
 colours. In addition to the colour posi-
 tions there are also preferably an off posi-
 tion 5 and a dim position 6, turning of
 115 the arm 3 to the latter causing the whole
 of the unit controlled by the particular
 panel to gradually dim down to off.

Above each dial 4 is preferably a pilot
 lamp 7 which is arranged to be on when-
 120 ever any hunting switch controlled by
 that dial is in operation. The operator
 can thus follow the operation of the
 apparatus even though the actual units
 are out of sight.

Beneath each hand wheel 2 is a switch
 8 which when off takes the unit out of
 control of the step controller without
 however changing the condition of the
 125 unit. This enables pre-setting to be

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effected, simply by switching 8 off, and turning the hand wheel 2 and arm 3 to the desired new position. The change only takes place when 8 is switched on again.

5 The switch 8 also enables the change of colour to be stopped while the dimmers are changing position from that corresponding to one position on the dial 4 to that corresponding to another, or during
10 dimming down when the arm 3 is at position 6.

Beneath the switch 8 is a row of colour control switches 9, in this case three, 9R, 9G, 9B as a three colour system com-
15 prising red, green and blue has been assumed. These switches are three position switches; in the mid position the respective colours are controlled by the step controller; when turned say to the left,
20 the respective colour is switched off independently of and without affecting the step controller and when turned say to the right, the respective colour is brought full on, again independently and without
25 affecting the step controller.

The master controls on the centre panel comprise colour master switches 10R, 10G and 10B, a preset master switch 11 and a load master switch 12. As shown the
30 switches 10 only have two positions, one in which the switch is on, i.e. the colours are controlled by the respective panel controls 2 or 9, and the other in which the respective colours in all units are extinguished independently of and without
35 affecting the panel controls. They can be arranged however to give a third position, in which the respective colours in all units are switched full on independently of and without affecting the panel controls
40 of and without affecting the panel controls but this is usually unnecessary.

The switch 11 corresponds in action to the switches 8 but controls all units simultaneously. The switch 12 in the off
45 position switches the lighting current off. Both switches 11 and 12 are independent of the panel controls, that is to say when switched on and off bring about the corresponding result without in any way changing
50 the conditions set up by the panel controls.

Obviously the complete system may comprise any number of units and a corresponding number of control panels; further any one panel can control several
55 units.

Figure 2 is an incomplete circuit diagram for a direct control system, and can be regarded as a wiring diagram for
60 the centre panel of Figure 1. For simplicity only one pole of the wiring is shown and some details omitted.

The three colours of the unit are indicated respectively by R, G and B. In
65 series with each is a dimmer resistance

13. As explained below these dimmer resistances are motor operated and the particular value of resistance established at each position of the respective arm 3 is
70 determined by a hunting switch 14. Each hunting switch is connected by an appropriate set of lines 15 to a respective row of studs 16 over which wipe contacts 17
75 on an arm 18 fast upon the shaft 2a of the hand wheel 2. The studs corresponding to the off position 5 of figure 1 are simply dead studs. Thus if the contacts 17 are energised each position of the arm 18 except the off position results in a definite setting of each dimmer 13. A low
80 tension supply is conveniently used in the control circuits and the energising of the contacts 17 is controlled by the switch 8. The supply from LT+ to the switch 8 and to the corresponding switches 8 on
85 the other panel is controlled by the master switch 11.

Each dimmer is provided with a bypassing contactor 19 and a series contactor 20. The low tension supply to the
90 coils of the contactors is controlled by the switches 9. When the contactors 19 operate the corresponding colours are brought full on independently of and without affecting the positions of the dimmers.
95 Similarly when the contactors 20 operate the corresponding colours are extinguished independently and without affecting the positions of the dimmers. As shown the contactors 20 break when energised, but they may work the opposite
100 way i.e. they may normally be energised to close their contacts and the switch 9 arranged to open them in the opposite position. Similarly the contactor 19 may
105 by-pass the contactors 20 as well as the dimmer resistance 13.

The low tension supply to the switches 9 is controlled by the master switches 10. In the on position of switches 10 the
110 supply is directed to the arms of all corresponding switches 9, in the off position it is independently directed straight to each corresponding contactor 20. Independent switching is necessary to prevent the switch 9 on one panel from setting in operation the contactors 19 belonging to other panels. If a third position for switches 10 is desired, this will
115 independently direct the supply straight to all corresponding contactors 19. The load master switch 12 independently controls all the contactors 20 which between them control the whole main supply from the positive main M to all units. Independent
125 switching is necessary to enable the contactors 20 to be separately controlled by switches 9 and 10.

Figure 2 will serve equally well for explaining a system with indirect bright-
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ness control. In this case the resistance 13 will represent potentiometers by which grid voltage is supplied to respective multi-electrode tubes or valves through which current is supplied to the units. This system has the advantage that grid current is almost negligible and there is therefore substantially no dissipation of energy in dimmer resistances, and the resistances can moreover be of lighter construction.

Figures 3 and 4 illustrate a convenient construction of motor dimmer for use in the circuit of Figure 2. The resistance 13 is in two banks 13a, 13b, tappings being led from each to a series of studs 22 set concentrically about a pivot 23 on which oscillates an arm 24 carrying a brush 25 which forms a bridge between one set of studs and the other. The current is led into one end of one bank 13 and out at the same end of the other bank and the brush 25 bridges more or less of the resistance according to its position and may at once end position break the circuit. The arm is moved from an electric motor 26 through reduction gear in a case 27, a crank arm 28 and link 29, while another arm 30, link 31 and arm 32 actuate the hunting switch housed in a case 33.

As shown in Figures 5 and 6 the hunting switch comprises a row of resilient fingers 34 which work between two stationary contacts 35, 36, and when the fingers are left free they bear against the contact 35. Connection is made to the fingers 34 from the appropriate studs 16 by the lines 15 (see Figure 2), while the contacts 35 and 36 are connected to respective contactors (not shown) which when energised cause the motor 26 to turn in one and the other direction respectively. In the case where electromagnetic clutches are used, these will be connected to the contacts 35, 36 instead of the motor controlling contactors. These contactors or clutches are also arranged to close contacts which switch on the respective pilot lamps 7 whenever they are in action. Upon a shaft 37 carrying the arm 32 is a row of cams 38 which actuate the fingers 34 through push rods 39. These cams comprise a main part of such diameter that when as shown a push rod is against it, the corresponding finger 34 is against contact 36. The end of each cam has a step 38a of such height that when a cam has turned until the respective rod 39 reaches this step the finger 34 then lies between the contacts 35 and 36 and when the cam has turned still further the rod 39 rides off it and the finger 34 abuts the contact 35 also as shown. The contactor or clutch which causes movement of the dimmer which produces counter-clockwise rota-

tion of the shaft 37 is connected to contact 36 and that which causes movement in the opposite direction is connected to contact 35. Then if the cams are correctly set and any finger 34 is energised by setting of the hand wheel 2 if that finger is not between the contacts 35, 36 i.e. if the dimmer is not in the position corresponding with the setting of hand wheel 2, the dimmer will be set in motion in the appropriate direction and will come to rest when the said position is reached.

Instead of using a reversible motor, the motors may rotate in constant direction and be provided with gearing driving two shafts in opposite directions either of which may be coupled to the dimmer by one of two electromagnetic clutches connected to the contacts 35 and 36 respectively. One such motor driving two shafts rotating in opposite direction may be common to a number of dimmers.

Figure 7 shows a preferred construction of hand control which prevents energising of intermediate studs 16, when the controller is moved from one position to the other. The shaft 2a is slidable endwise but is normally pressed outwards by a spring 40 which urges the arm 18 and contacts 17 against the studs 16. At the same time a peg 41 on the arm 3 enters one of a series of holes 42 in the dial 4. This peg prevents the hand wheel 2 from being turned unless it is first pressed inwards, thus moving the contacts 17 away from the studs 16; it also ensures that contact can only occur when the contacts 17 are fairly and centrally opposite the studs 16.

Figure 8 shows diagrammatically a scheme for mechanically effecting a repeating cycle of changes in apparatus of the above described kind. In this case the studs 16 connected to the fingers of the hunting switch are set in a circle round the shaft 2a, but they may comprise more than one cycle in the complete circle; further, the studs 16 are set such a distance apart that the contacts 17 on the arm 18 cannot be bridged in passing from one to the next. Upon one of the shafts 2a is fast a ratchet wheel 44 fed forward step by step through a pawl 45 by a crank 46 driven by a motor 43. The steps are made equal in length to the spacing of the studs 16 and the speed made such that at least the time of the longest colour change passes between each step. The shaft 2a carrying the wheel 40 conveniently drives any other shafts desired by sprocket and chain gearing 47, the sprocket preferably incorporating free wheels so that the phase relation between one shaft and another can readily be changed.

Another scheme for mechanically affecting a repeating cycle of changes is to use apparatus similar to that disclosed in our specification No. 411,868. In this case however each drum switch will comprise for each colour in the units as many cam plates as there are strengths of colour in the cycle. These plates will each control the supply through one line 15 leading to the respective hunting switch.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed we declare that what we claim is:—

1. A control system for colour lighting apparatus of the type set forth, comprising a controller in the form of a step switch (operated for example by a hand wheel), and hunting switches as hereinbefore defined associated with the brightness controls said step switch determining the stopping positions of all hunting switches associated with one lighting unit and themselves actuated by or in conjunction with the brightness control.

2. A control system according to claim 1 in which the brightness control is effected directly.

3. A control system according to claim 1 or 2 in which a switch is provided which is adapted to remove the control from the step which, independently of and without affecting the setting of the brightness control produced by such step controller.

4. A control system according to claims 1, 2 or 3 in which a colour switch is provided for each colour in the unit which is adapted to control the respective colour independently of and without affecting the setting of the corresponding brightness control provided by the step switch.

5. A control system according to any preceding claim comprising a series of units and step switches in which a master preset switch is provided adapted to remove the control from the whole of the step switches, and if desired from the colour switches where provided, indepen-

dently of and without affecting the setting of the brightness controls produced by such step switches and independently of the colour switches if any.

6. A control system according to claim 5 in which a master colour switch is provided for each colour in the units which is adapted to control the respective colour independently of and without affecting setting of the corresponding brightness controls produced by the step switches and independently of the colour switches if any.

7. A control system according to any preceding claim in which a master load switch is provided adapted to extinguish the whole of the units independently of and without affecting the setting of the brightness controls produced by the step switch or switches, and also independently of any other switches.

8. A control system according to claim 1 or 2 in which the step switch is stepped on by a motor drive so that a repeating cycle of changes is produced mechanically.

9. A control system according to any of claims 1—7 having the step switch constructed substantially as described with reference to Figure 7.

10. A control system according to any preceding claim having the hunting switch and dimmer constructed as described and shown in Figures 3 and 6.

11. A control system according to any preceding claim having the controls grouped and arranged as described and shown in Figure 1.

12. A control system according to claim 8 as described and shown in Figure 8.

13. A control system for colour lighting apparatus having a circuit as described and shown in Figure 2.

Dated this 11th day of April, 1935.

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Fig

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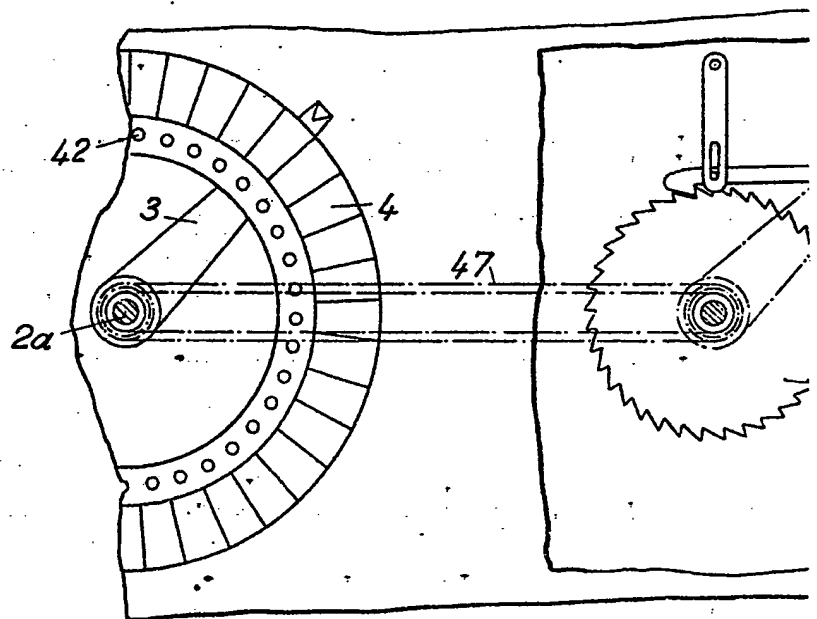
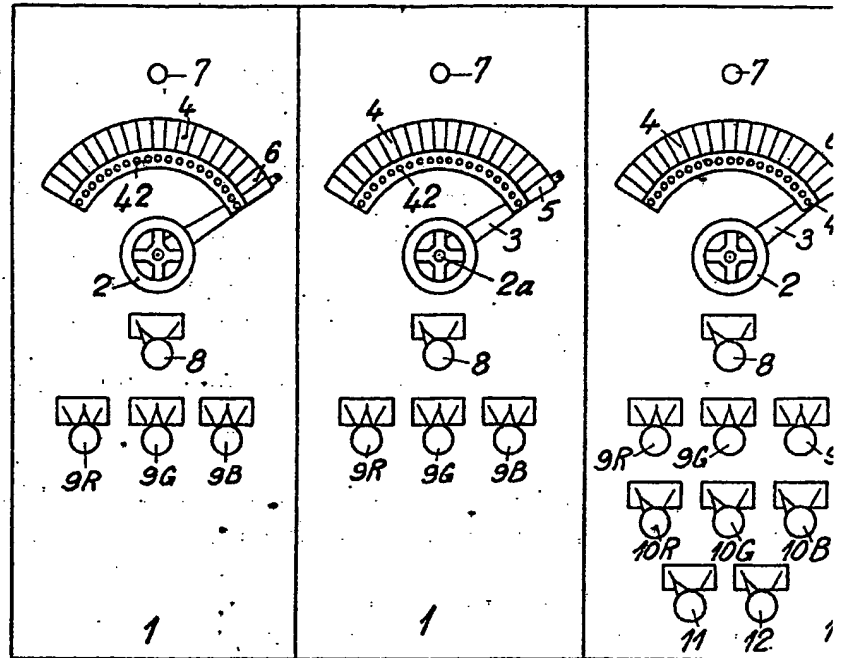


Fig. 1

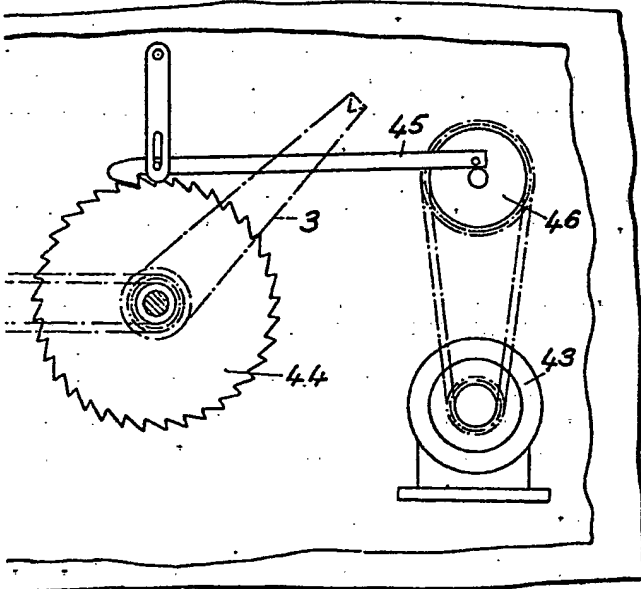
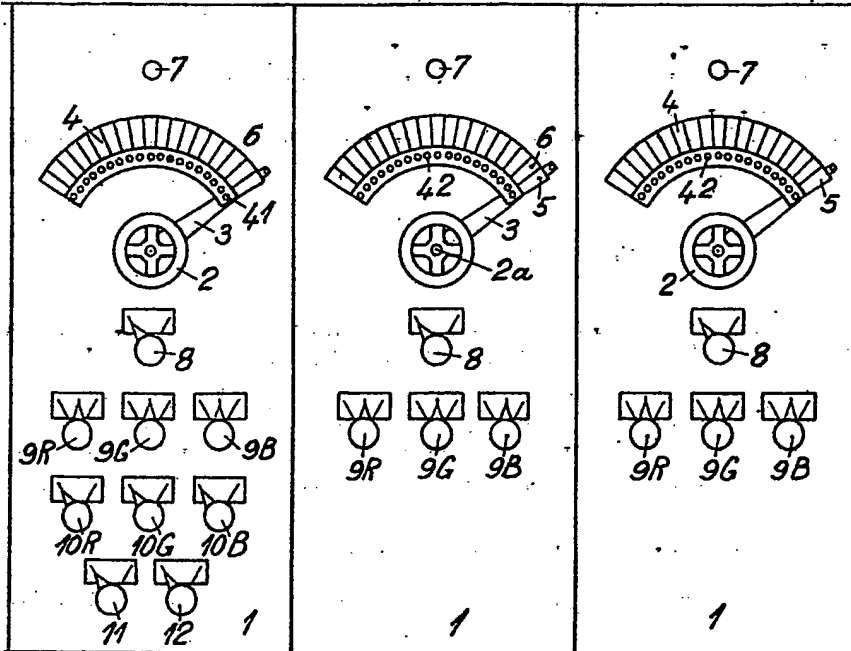


Fig. 8

Fig. 1

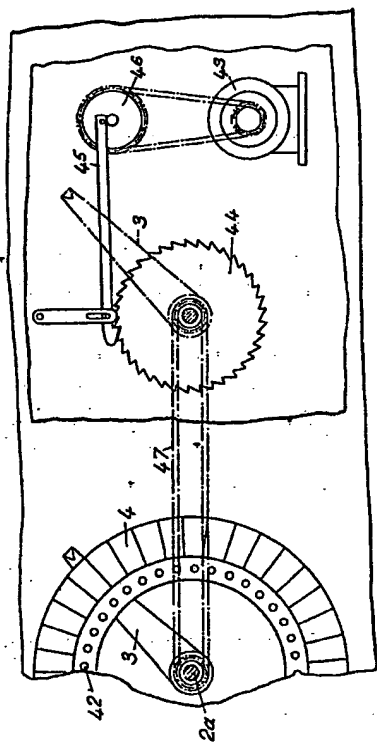
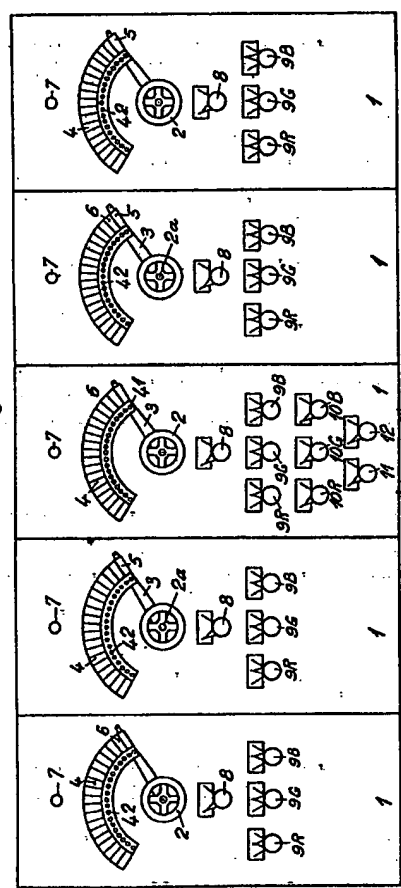
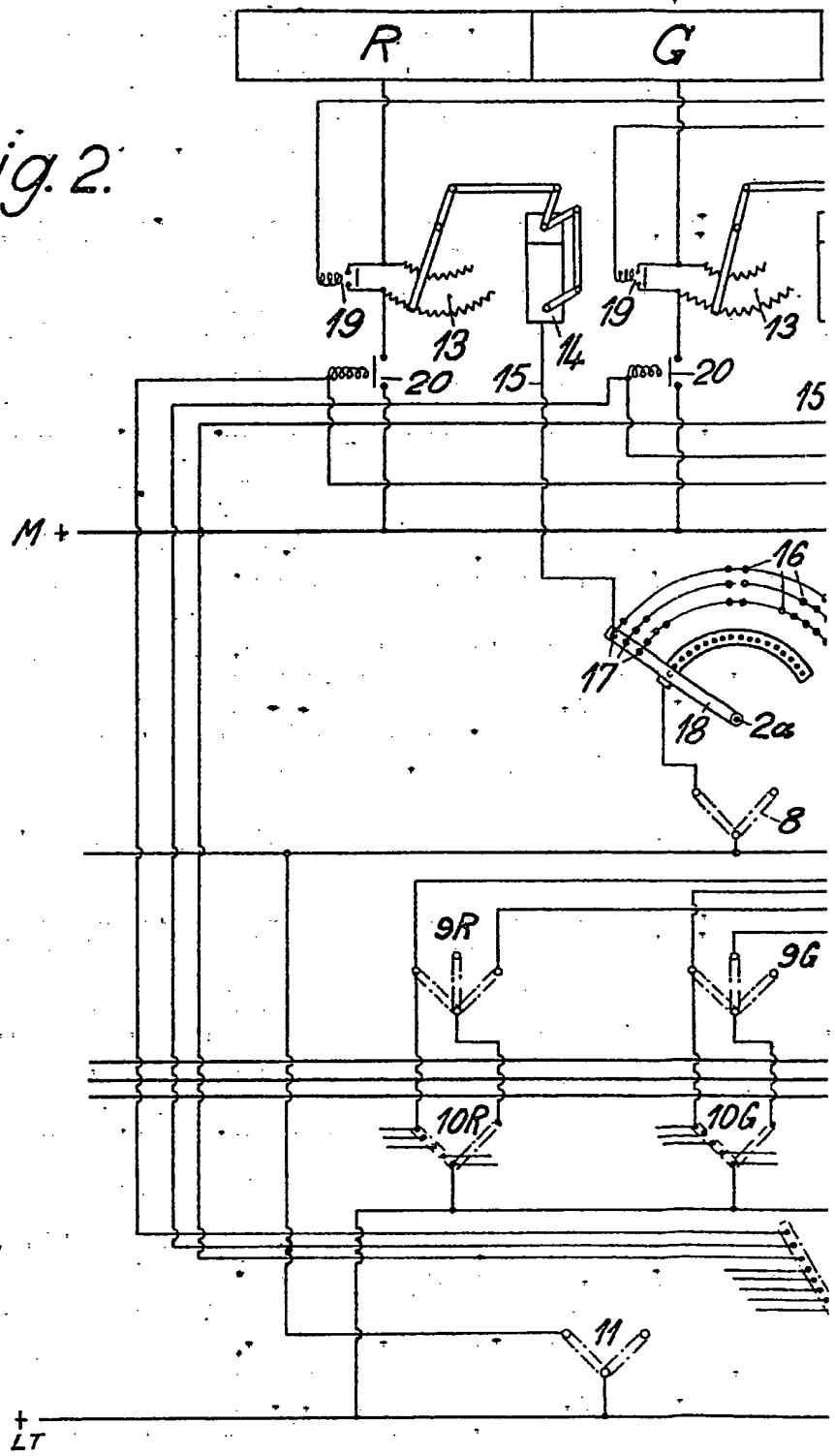


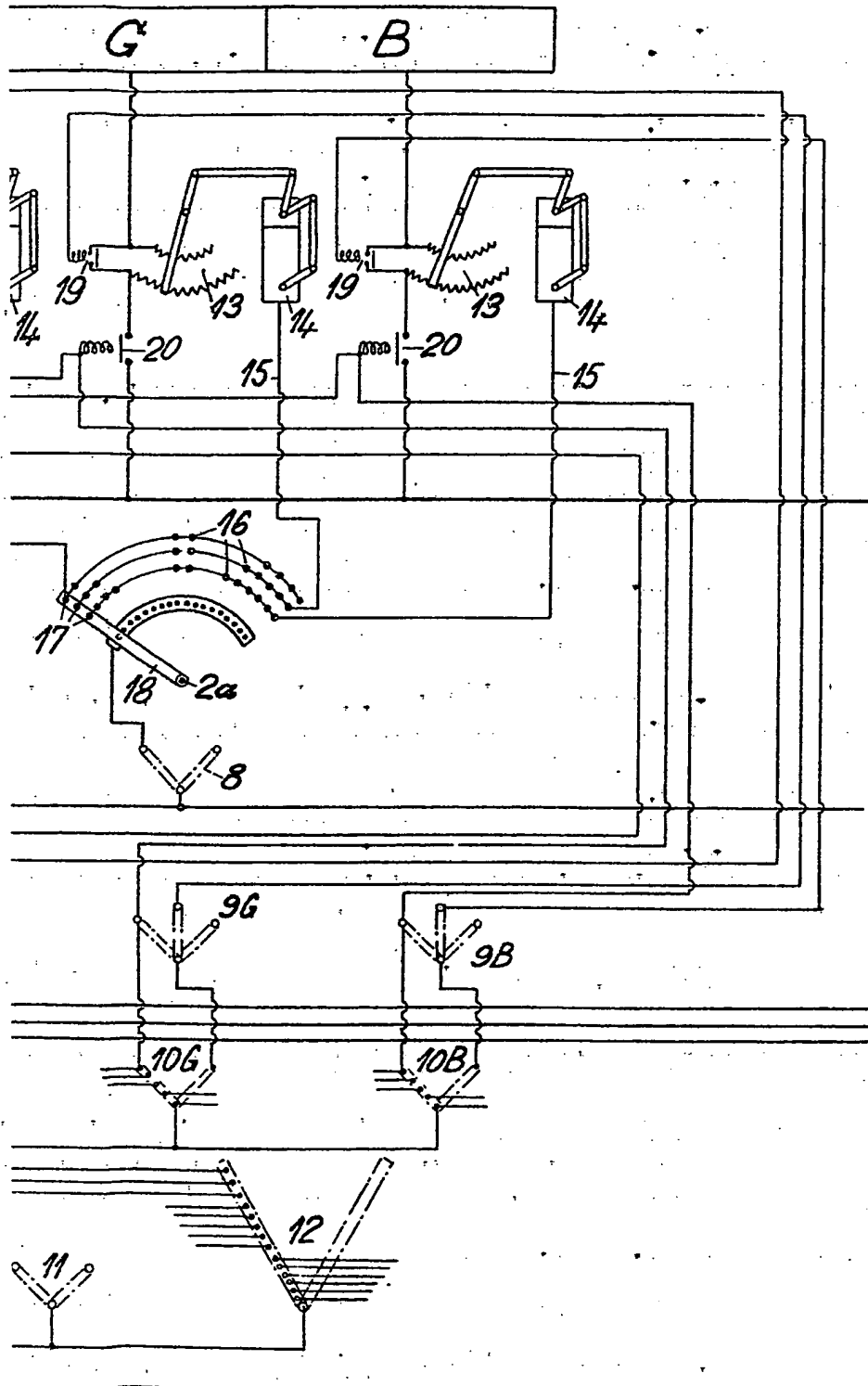
Fig. 8

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Fig. 2.

[This Drawing is a reproduction of the Original on a reduced scale.]





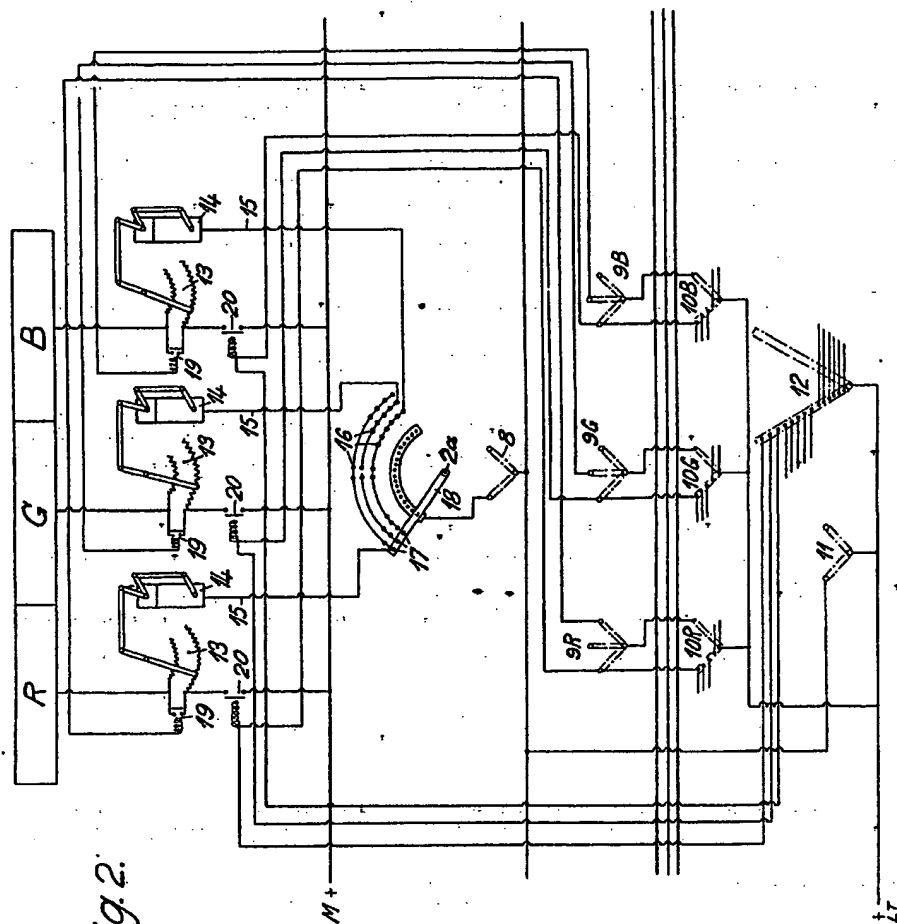


Fig. 2.

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Fig. 3.

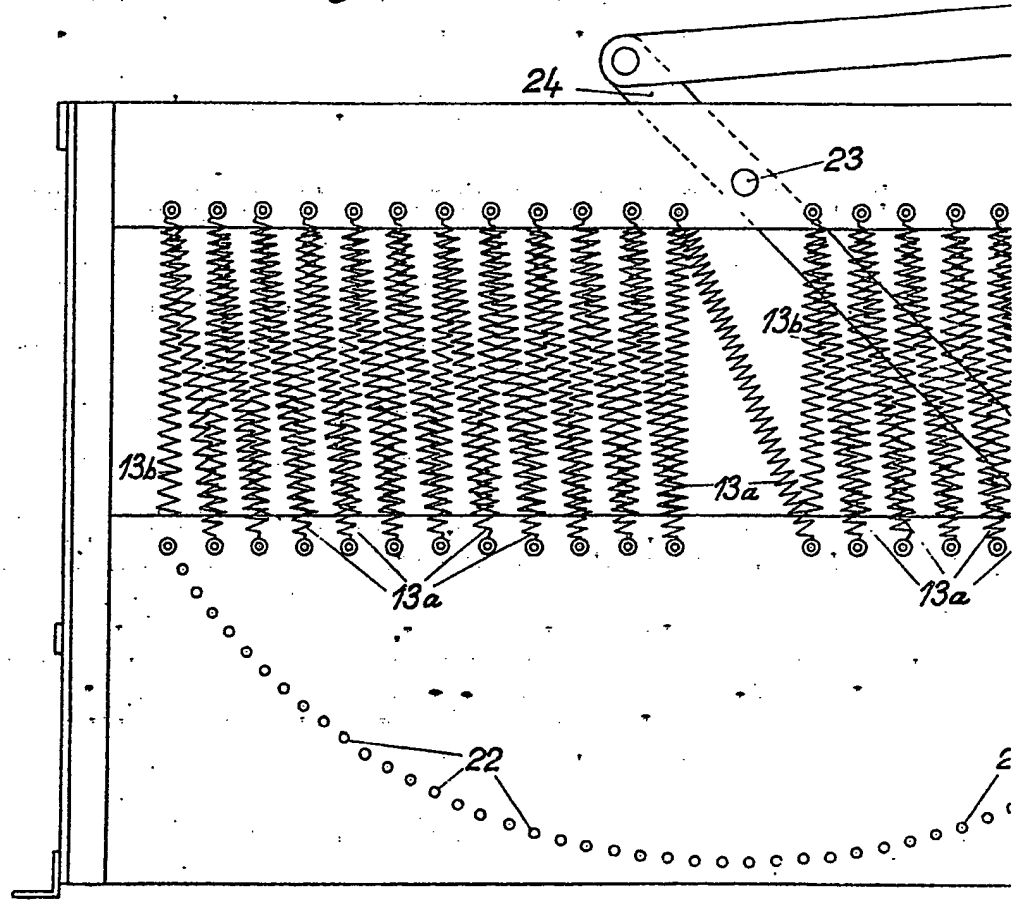
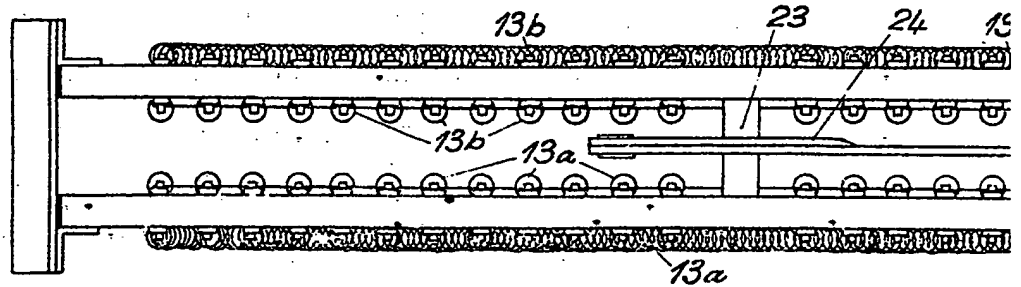


Fig. 4.



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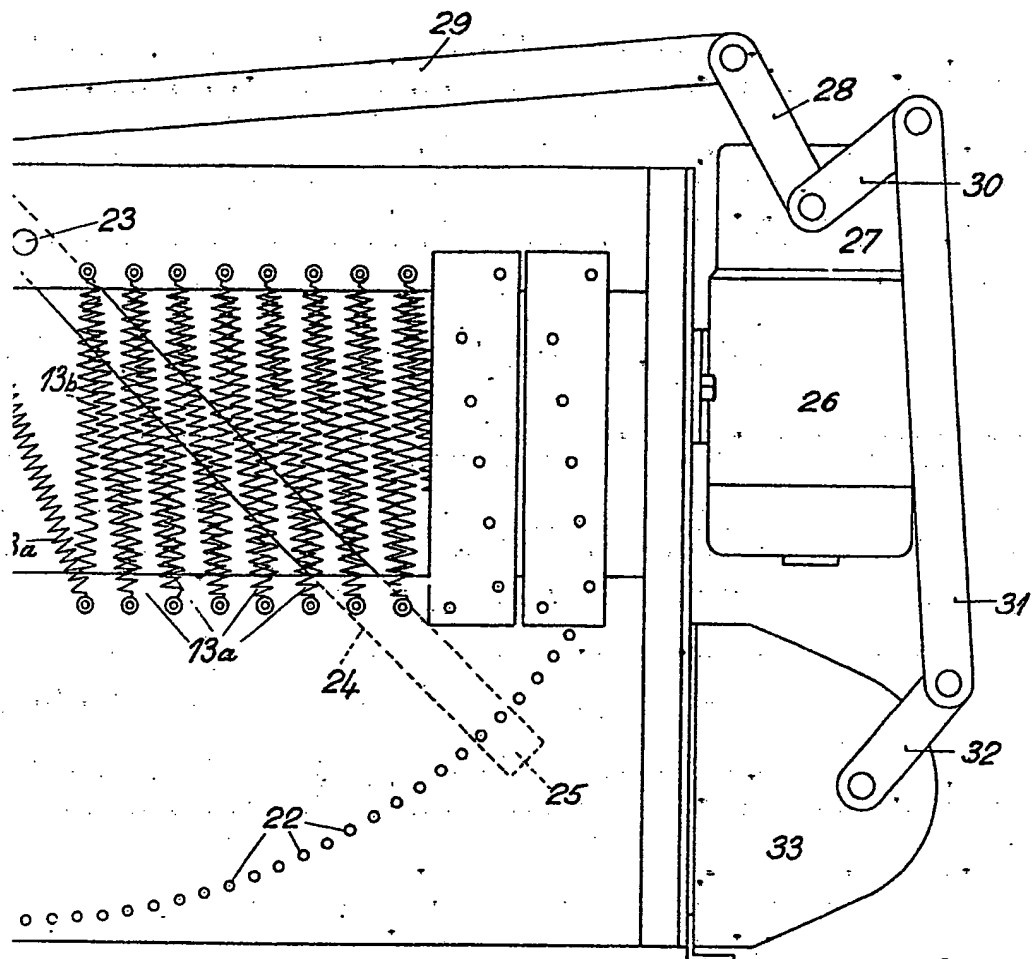
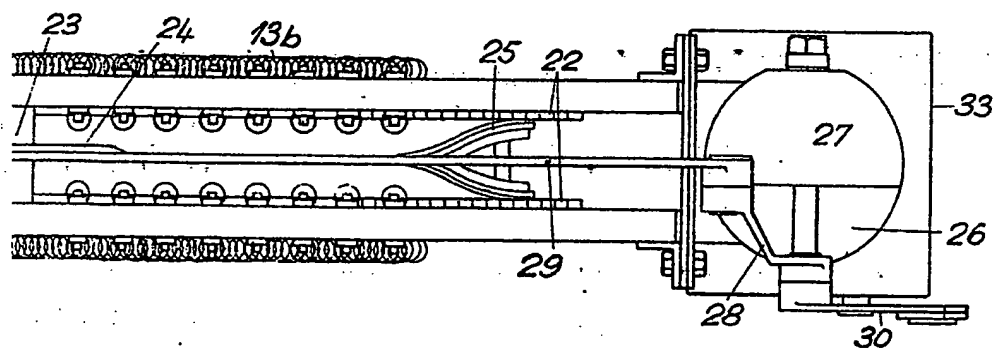


Fig. 4.



441,461 COMPLETE SPECIFICATION

Fig. 3.

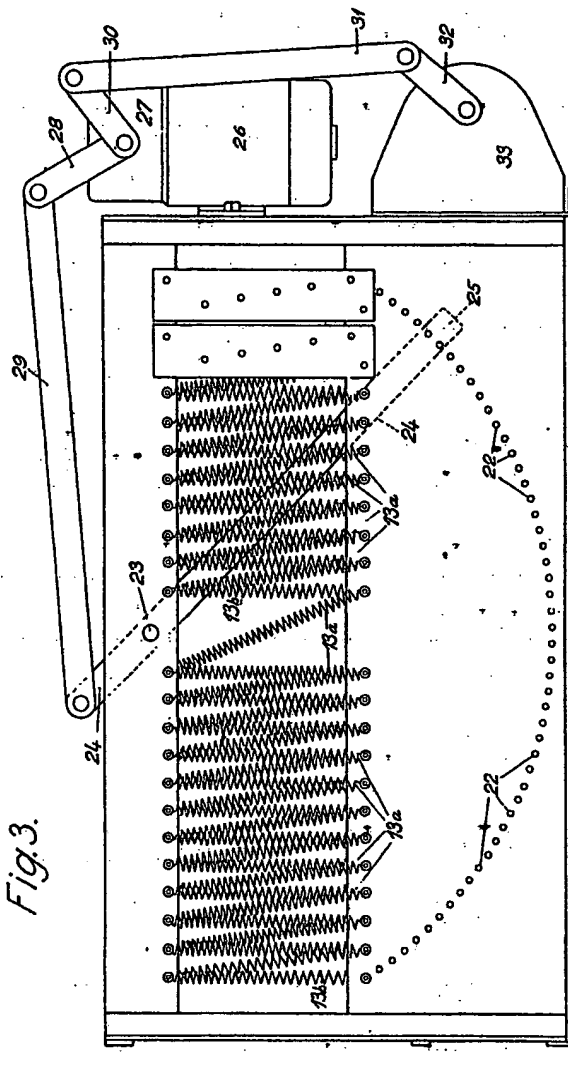
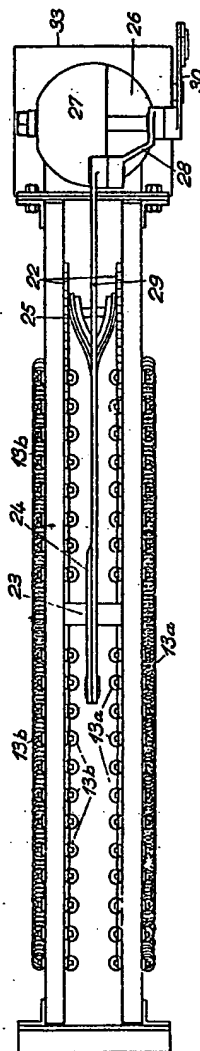


Fig. 4.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig 5

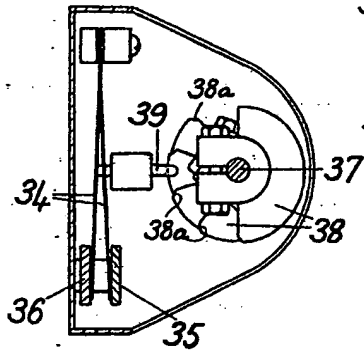


Fig. 6

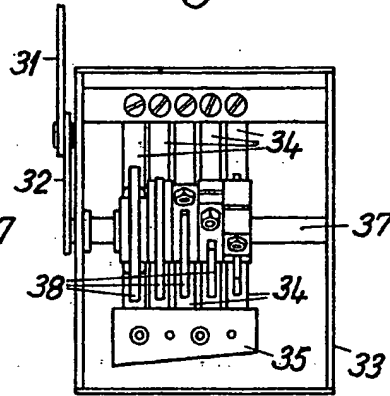
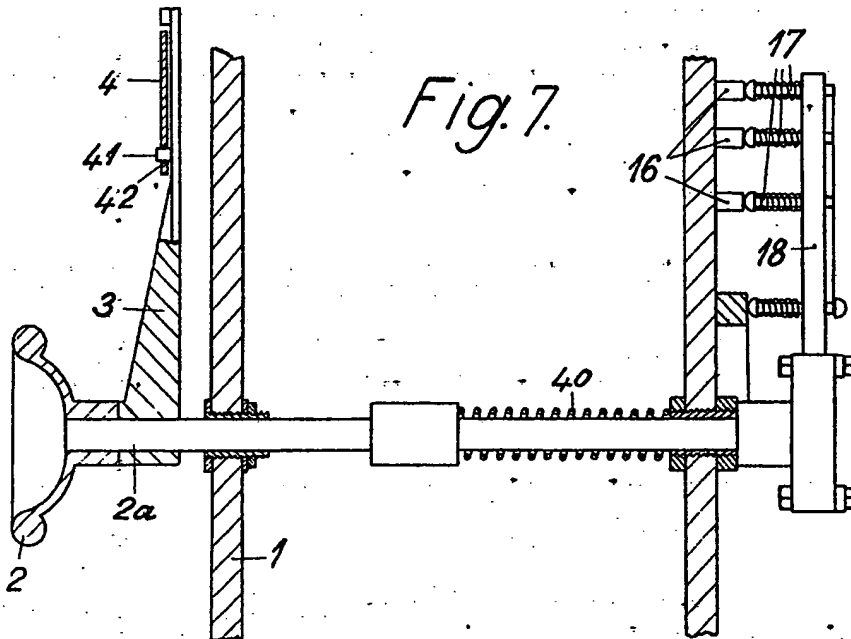


Fig. 7



[This Drawing is a reproduction of the Original on a reduced scale.]